MAPS OF SNOW-COVER PROBABILITY FOR THE NORTHERN HEMISPHERE

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ABSTRACT

Map analyses are provided depicting the probability of snow-cover 1 inch or more in depth at the end of each month from September through May for the Northern Hemisphere.

1. INTRODUCTION

Recent work dealing with thermodynamic [1] and synoptic [8] aspects of long-range forecasting has emphasized the importance of considering the heat balance of the earth and the atmosphere when dealing with the long-term evolution of the atmospheric circulation. An important factor in such a heat balance is the albedo of the earth's surface and this in turn is critically dependent upon the snow-cover distribution.

Thus a need exists for broadscale climatic analyses depicting the areal extent of snow cover throughout the year. While map analyses of average snow depth and average dates of first and last snowfall are readily available, data dealing with snow-cover probability remain somewhat fragmented and in graphic or tabular form. The present study attempts to assemble and present in map form (figs. 1–9) all readily available data on the probability of snow cover 1 in. or more in depth at the end of each month from September through May. The critical depth of 1 in. was arbitrarily selected as the level at which snow cover begins to affect markedly the thermal properties of the surface. Recent research [6] verifies that with this snow depth the surface albedo is rapidly changing from its minimum value with no snow to its maximum possible value with snow.

2. DATA AND ANALYSIS

The most extensive summary of snow-cover data available to the authors was a publication of the U.S. Army Engineers [2] which provides snow-cover probabilities in graphical form for much of the Northern Hemisphere. Data sources and periods of record used in the preparation of this publication vary widely; the interested reader may obtain such details from the referenced source. In this instance, as was the case in all other data sources considered, snow-cover probabilities are empirical in nature.

To supplement this primary data source, empirical snow-cover probabilities were computed for the 1931–50 period for a network of 110 stations in the United States from data included in U.S. Weather Bureau Station Record Books (available on microfilm from the Atmospheric Sciences Library of ESSA). Canadian snow-cover data were extracted from a recent publication [10]. This was augmented for May and September by data from additional stations during 1940–64, obtained from monthly published records [5].

Analyses for China and Korea are based upon data published by their respective meteorological offices [9], [4]. Both sources give the average number of days with snow cover for each month. These frequencies were assumed to apply at mid-month, allowing estimation of end-of-the-month values by interpolation. Since periods of record were short in many instances, erratic patterns not supported by topography were smoothed.

Although no snow-cover frequencies were readily available for Japan, an atlas [3] provides normal depth of snow for each month. As a rough approximation, it was assumed that a normal depth of 2 cm. approximated a 50 percent probability of 1-in. snow cover. Although such estimates are more representative of mid-month, no interpolations were made in view of the assumption made.

Snow-cover probabilities over the British Isles were estimated from U.S. Weather Bureau [14] monthly summaries of the number of days with snowfall and days with snow lying (more than half of the surrounding country covered by snow). The latter statistic, taken to represent snow cover as considered by this report, was available for only a few scattered locations. However, by establishing the ratio of the two quantities where both were available, the number of days with snow lying was approximated at neighboring stations from the observed number of days with snowfall. Although such estimated frequencies are most applicable to mid-month, no interpolations were made to obtain end-of-the-month values, again because of the type of data available and the assumptions employed.

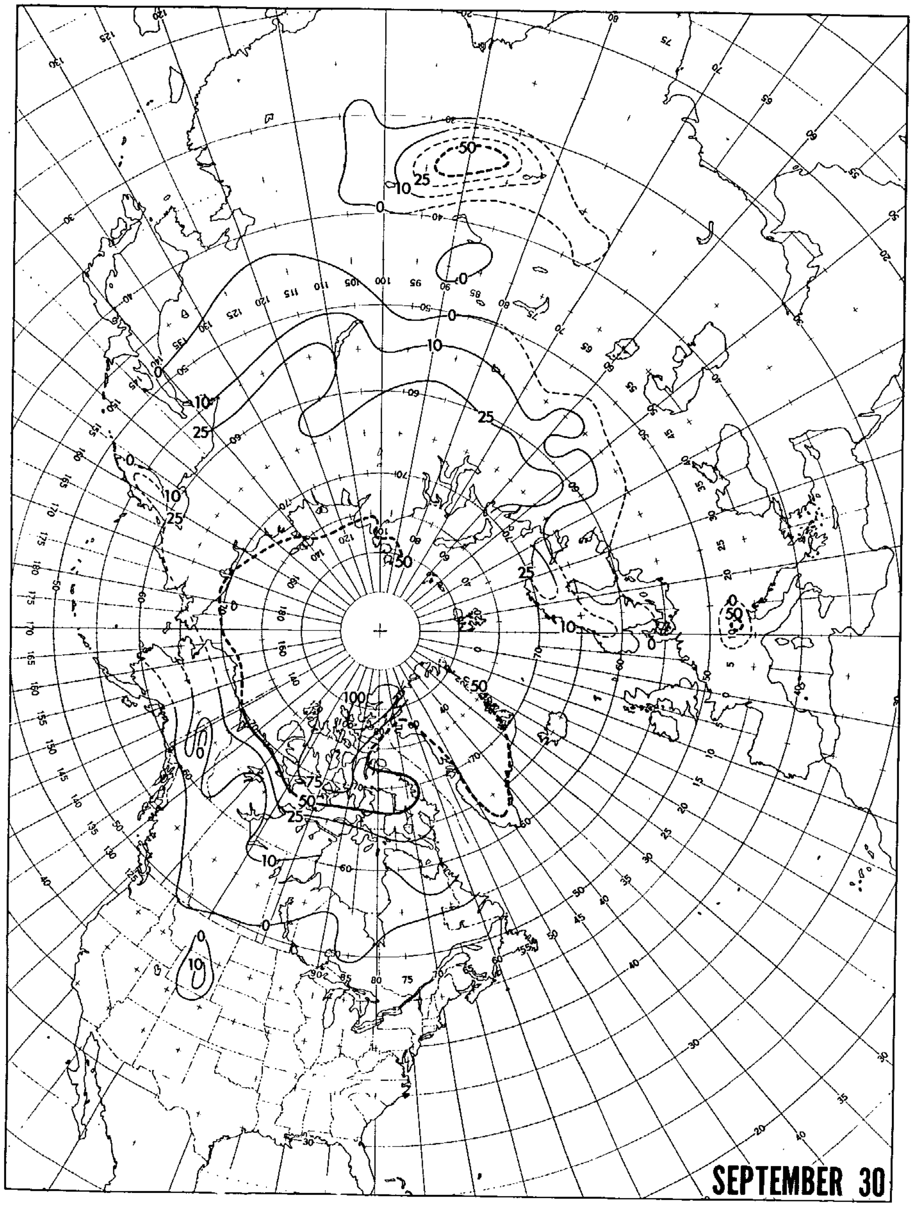
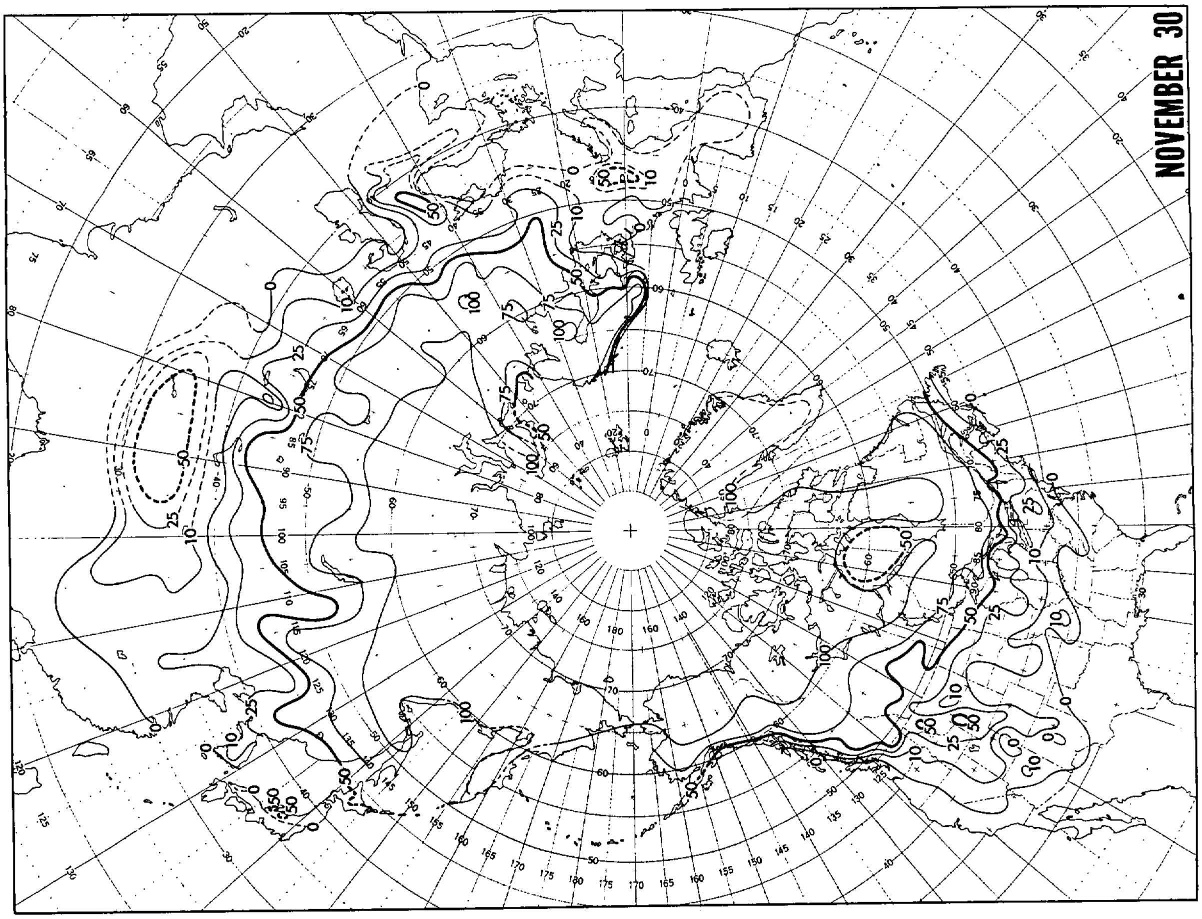


Figure 1.

FIGURES 1 through 9.—Probability (percent) of 1 in. or more snow cover at end of month, September through May, respectively. Dashed lines indicate analyses not supported by adequate data. Note omission of intermediate contours in some areas.



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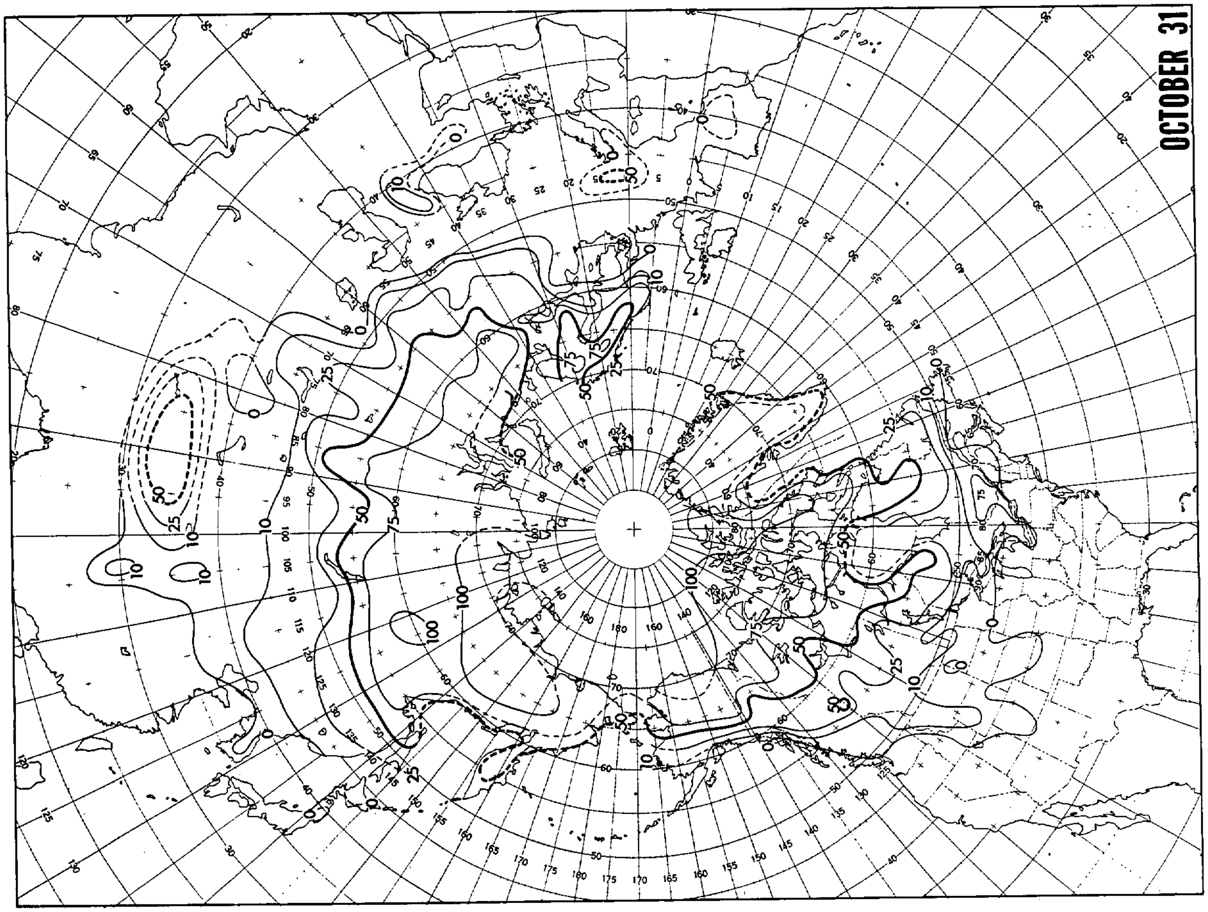

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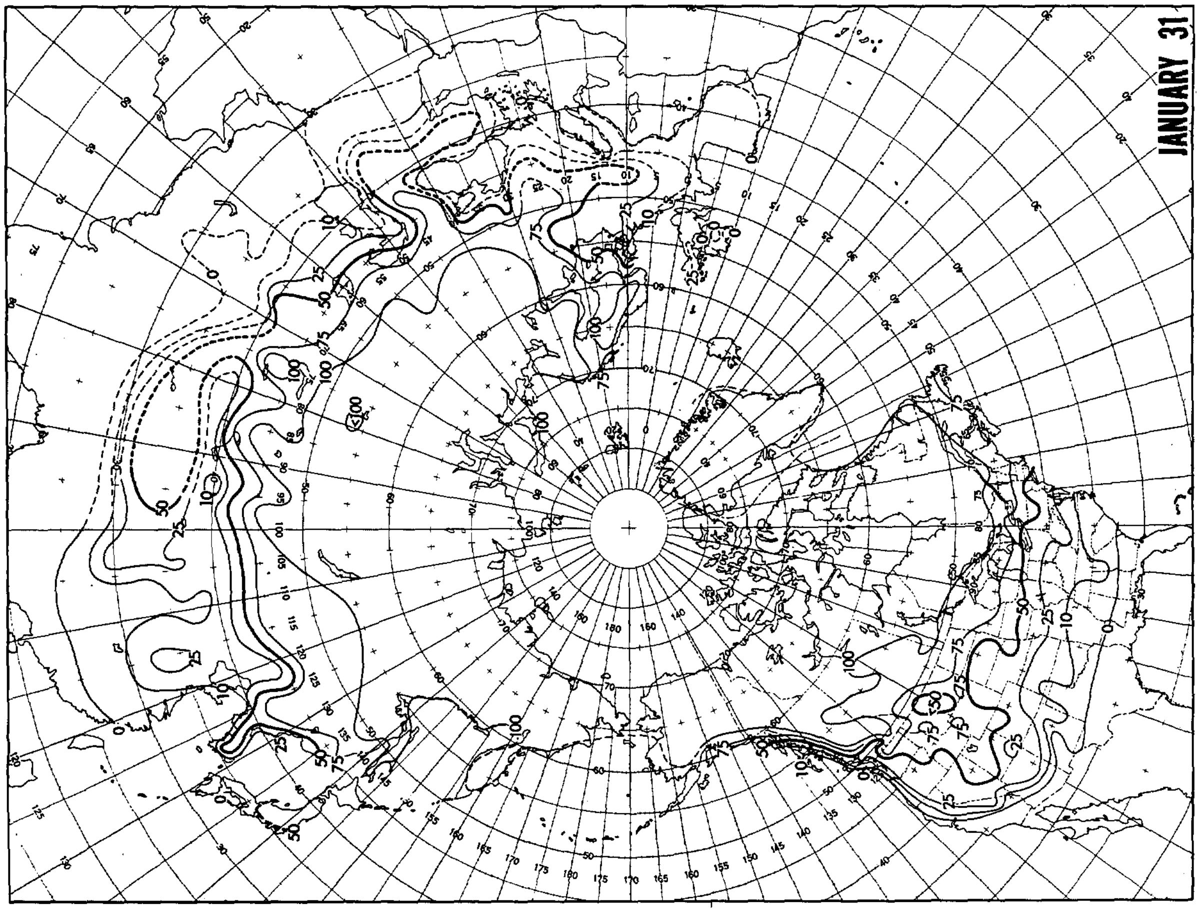

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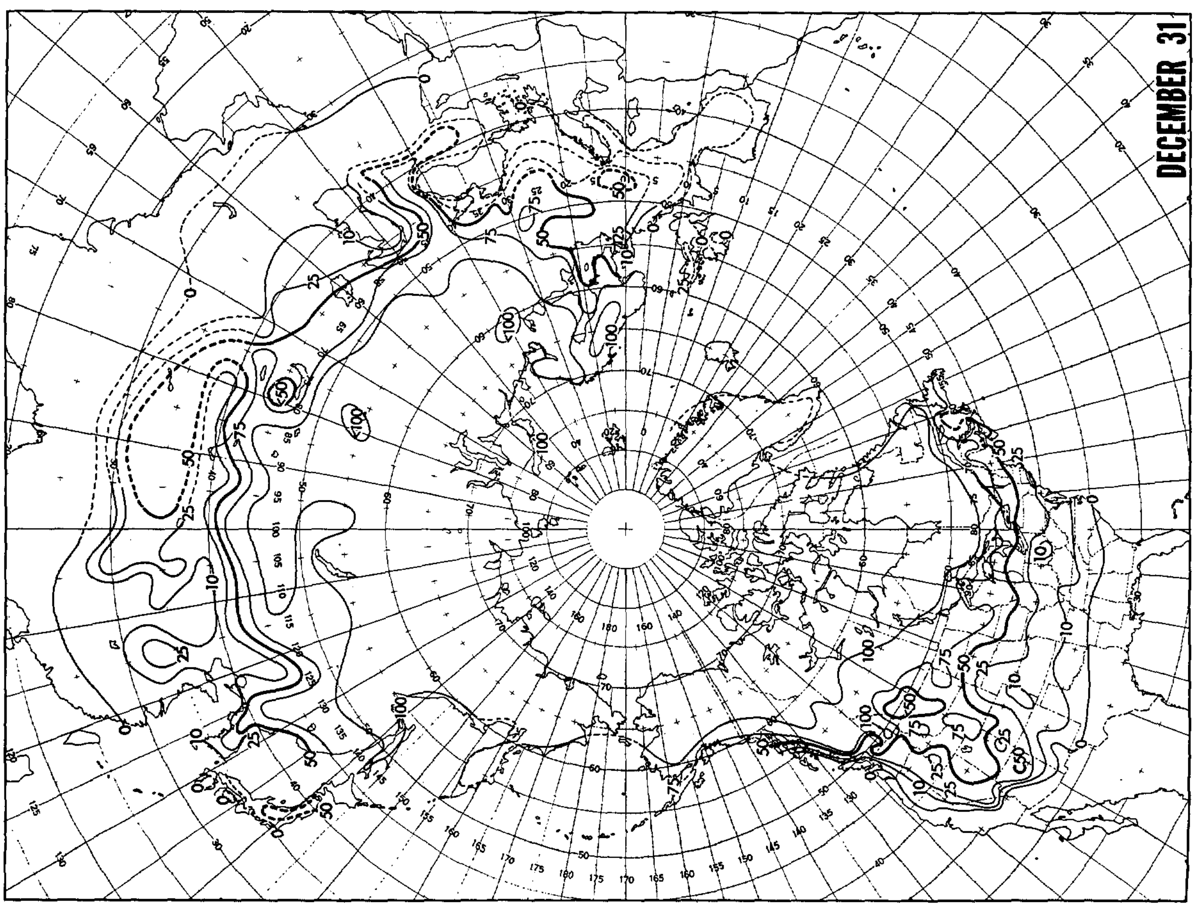

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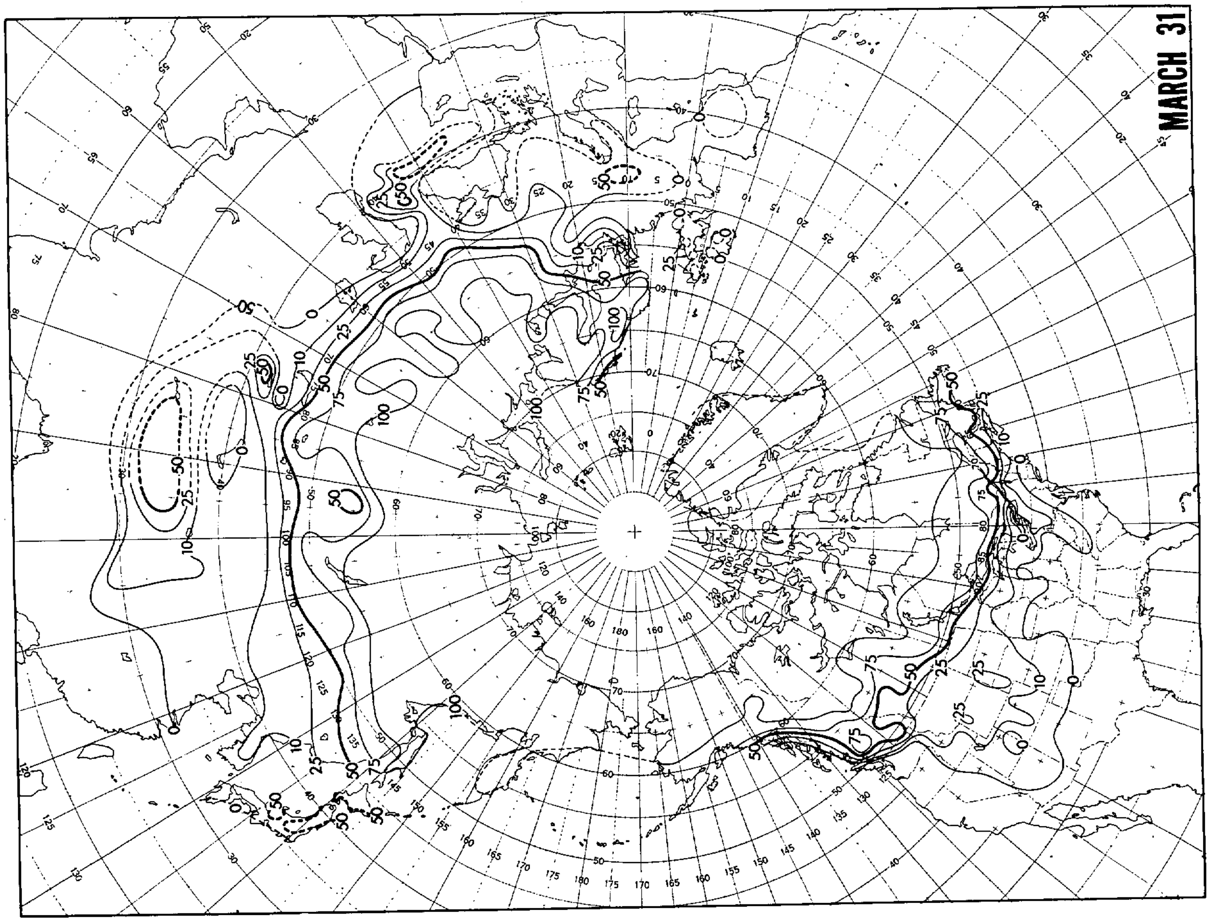

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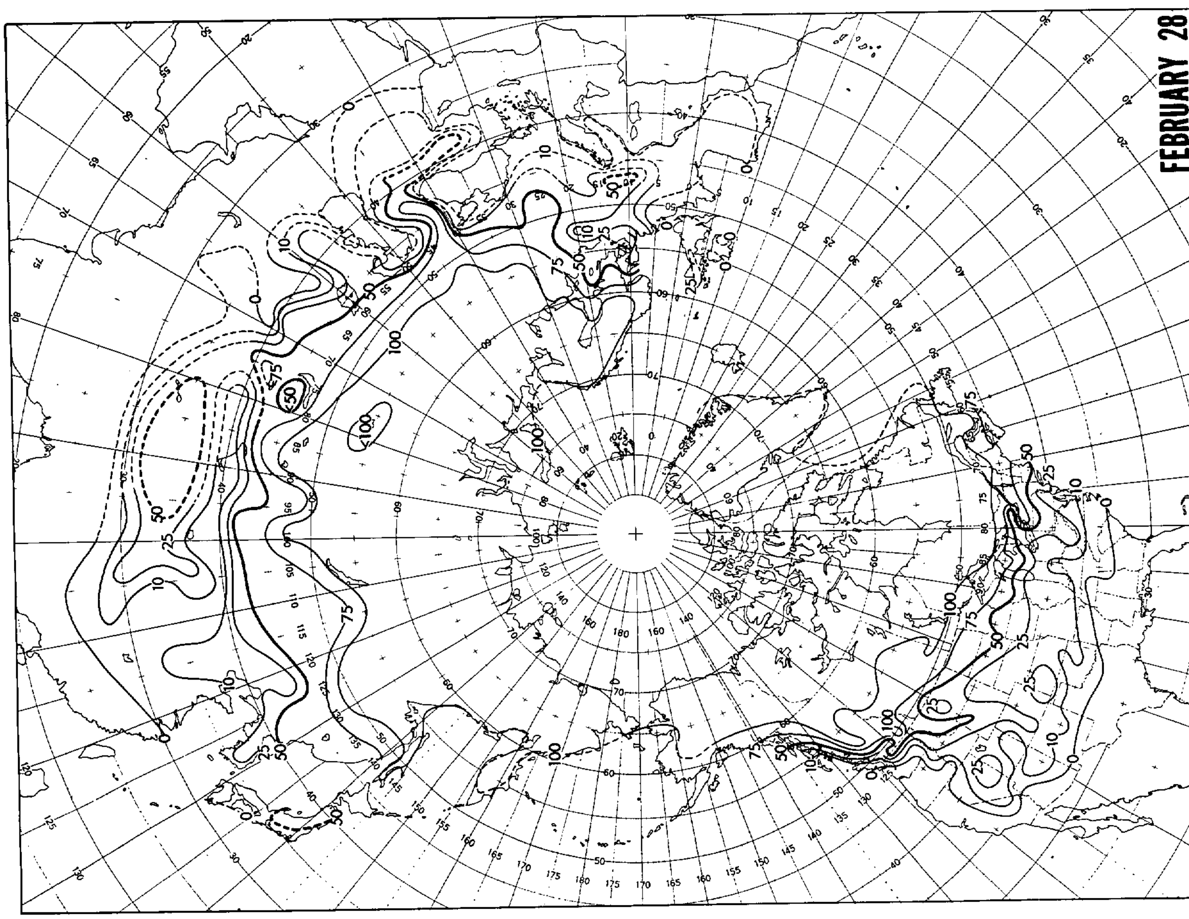

Figure 6.

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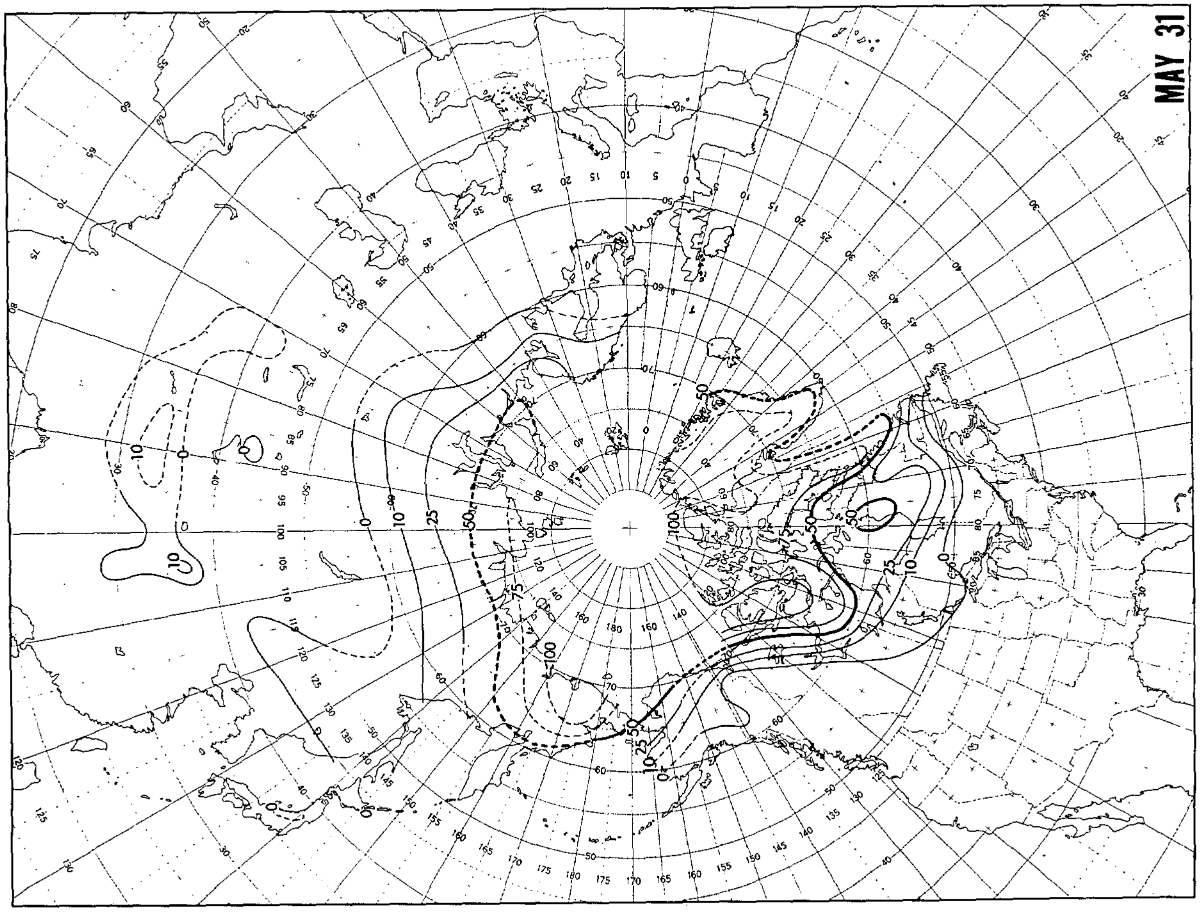

Figure 9.

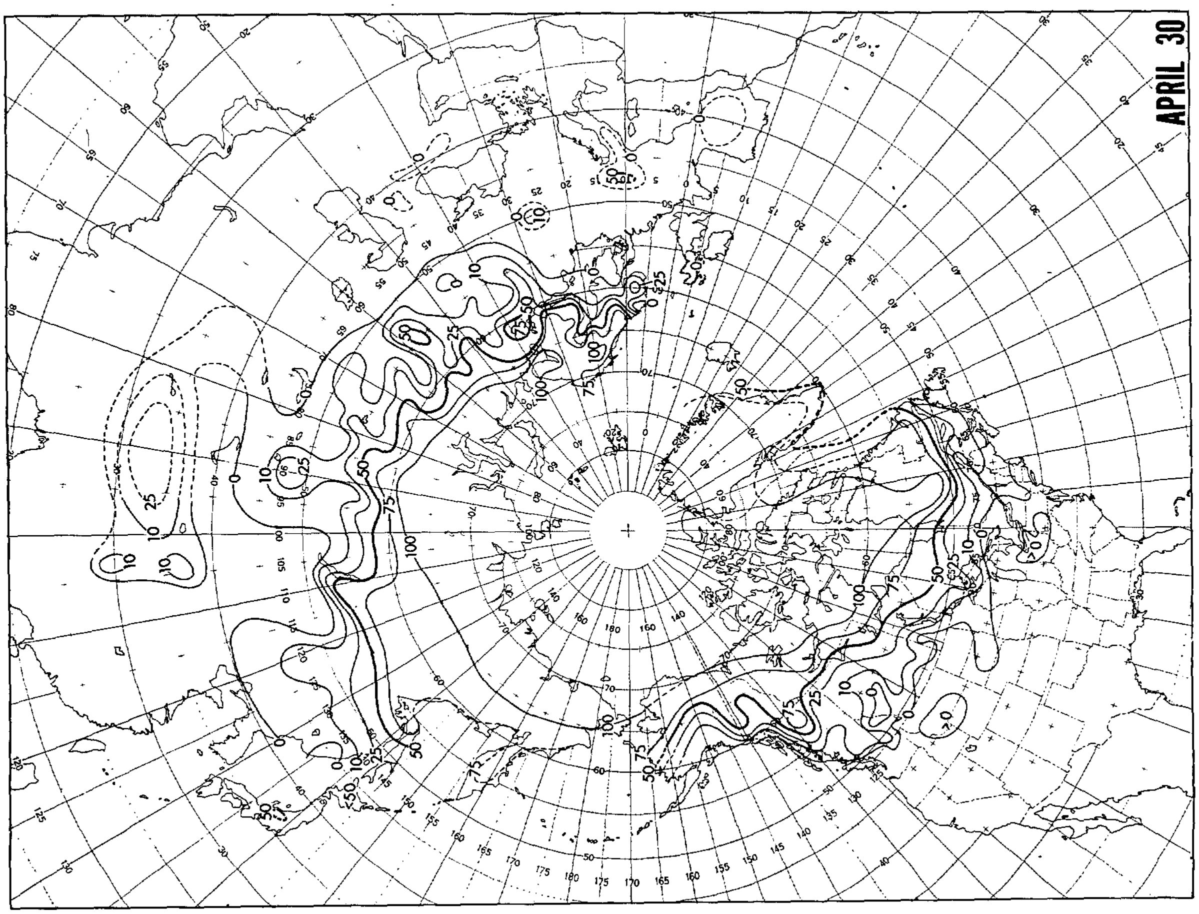

Figure 8.

Over the Tibetan Plateau only a rough approximation of snow extent was possible from some temperature—snow-cover relations derived by Manley [7] for the British Isles and from unpublished hemispheric maps of normal surface air temperature prepared by R. Taubensee of the Extended Forecast Division. Such an approach was deemed justified since even a rough estimation was desired and a few snow-frequency observations were available in the area to calibrate Manley's relationship. Unpublished maps based on satellite observations of snow-cover extent, prepared by the National Environmental Satellite Center since March 1966, have also been useful in locating the zero-probability snow line in this region of little or no conventional data.

A similar procedure was followed in areas such as Turkey, the Alps, and Greenland where no data were readily available. In all such instances analyses not supported by observed snow-cover frequencies are shown as dashed lines. Dashed lines were also used where the zero snow-cover probability line has been estimated on the basis of the occurrence or non-occurrence of snow as reported in the climatological atlases. Since depiction of the large-scale snow-cover distribution was the purpose of this survey, no estimates have been provided for certain limited areas, such as Iceland, where data were not readily available. In the case of Arctic regions, the interested reader is referred to atlases dealing with sea-ice distribution (e.g., [12], [13]). Such data have been used in the present survey to assist in locating the normal snow line over northern lakes and seas.

The accompanying maps (figs. 1–9) have obvious limitations in mountainous areas. Although some attempt has been made to account for gross mountain effects, analyses generally reflect conditions at primary weather stations located at relatively low elevations. Thus our analyses undoubtedly underestimate snow-cover probabilities at high elevations. Weekly snow-cover probabilities prepared for the United States by the Thoms [11] also suggest that this is so. Unfortunately, differences in the definition of snow cover, in period of record, and also in results in non-mountainous areas preclude the use of these analyses in the present study.

As is apparent from source references, data used in this survey were drawn from a variety of time intervals. These vary from pre-1915 data in the case of most of the Soviet Union to the early 1960's in the case of Canada. Thus it is evident that secular climatic changes may limit the usefulness of the accompanying maps. No attempts were made to compensate for climatic changes in view of the variable quality of the assembled data and an urgent requirement for final analyses. Furthermore, the prospects for successfully adjusting snow-cover probabilities to a standard period do not appear bright because of the joint dependence of snow cover upon temperature and precipitation. Nonetheless, the present study represents a first step in hemispheric analysis of snow-cover probability and should prove useful until conventional hemispheric data for a uniform period augmented by satellite coverage in remote areas becomes available.

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